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NEWS OF THE COMMISSION ON PLANETARY PHYSICS (SELECTED ARTICLES)

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PREPARED BY:

TRANSLATION SERVICES BRANCH
FOREIGN TECHNOLOGY DIVISION
WP-AFB, OHIO.

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Practice of Determining the Temperature of Individual Parts of Lunar Surface

by

Yu.N.Chistyakov

This report contains preliminary results of measuring the temperature of individual sections of the lunar surface with a dimension of 1.'5 X 1.'5. Observations were carried out with the aid of a vacuum thermoelement with a sensitivity of $1\frac{\mathrm{Ov}}{\mathrm{vt}}$, set up in Newton focus of 13" of the reflector at the Abastumansk Observatory. Analysis was made by the Menzel method, somewhat modified by the author. The amount of water vapor determining the absorption of planetary heat in the atmosphere, was calculated in accordance with Hann formula governing absolute humidity at the surface of the Earth.

The following results have been obtained:

1. Temperature of the subsolar point near full moon (phase angle + 17.2) equals 400°±30°K.

2. Temperature of seas is higher than the temperature of close by continents.

3. The ratio of radiometric albedo to the one visual for individual sections is equal to such a ratio of albedo average over the disk.

The determination of temperature of upper layer of the lunar crust appears to be an effective means of investigating its structure. Most complete data on the temperature of the lunar surface were obtained by Pettit and Nikol'skiy by thermoelectric measurements [1, 2]. In the USSR the determinatio of temperature of individual narrow zones of the lunar surface was undertaken for the first time at Pulkovo by A.V.Markov and the author [3] with the cooperation of M.S.Zel'tser. This report contains results of measuring the temperature of surface sections, having angular dimensions 1.'5 X 1.'5. Such an investigation is of double interest. First of all, a study of the change in surface temperature of sections, belonging to various forms of outlines and situated in a row, but in different sections of the disk, may reveal the heterogeneity of their structure. On the other hand, a comparison of temperatures, derived by the optical method, i.e.with the aid of a thermoelement, and by radio methods will enable to define more closely the magnitude of heat conduction and to compile a more detailed chart of the structure of upper layers of the lunar crust.

Unfortunately, because of unfavorable weather the author has not succeeded in obtaining sufficiently larger observation material.Consequently the results have a preliminary nature.

When computing the temperatures was employed a method, introduced by Menzel [4]. The idea of the method lies in the following.Each section of the Moon is measured twice: with water or glycerin filter and without same. When observing with filter from the total energy s ream , coming from the Moon, is separated a part, due only to light reflection. Deducting the value,corrected for partial absorption in filter,from the summary stream, it is possible to obtain a magnitude of the stream,due only to natural thermal emission. It can be calibrated in accordance with the magnitude of the reflected stream, provided the solar constant and reflectivity of the Moon are known, and they can be expressed in units of energy, or in temperatures.

Assuming for the i-section of the surface at a certain phase angle alpha $J_i^{\Sigma}(\alpha)$ the rejection of the galvanometer when observing without a filter, i.e.rejection due to summary flow.

$J_i^{\Phi}(\alpha)$- rejection when observing through filter, i.e. rejection, due to reflected stream (beam), by partially weakened filter

r_{Φ} - passing by filter of reflected radiation.

Then the rejection, due to totally reflected beam, will be equal to $j_i^{refl}(\alpha) = \frac{J_i^{\Phi}(\alpha)}{r_{\Phi}}$ and the rejection due to beam of thermal radiation

$$J_i^{\text{тк}}(\alpha) = J_i^{\Sigma}(\alpha) - \frac{J_i^{\Phi}(\alpha)}{p_{\Phi}}. \qquad (1)$$

We will designate these values , but liberated from absorption in the instrument and in the atmosphere, respectively $I_i^{\Sigma}(\alpha)$, $I_i^{refl}(\alpha)$ and $I_i^{tk}(\alpha)$

It is apparent, that

ik $$I_i^{\text{ик}}(\alpha) \sim E_i^{\text{ик}}(\alpha) \sim \sigma T_i^4(\alpha), \qquad (2)$$

where I_i (α) - thermal energy, emitted by i-point. T_i (α) - its temperature.

In role of a standard for calibration it is possible to use any j-yu point, measured at any given other phase angle α'. For it

$$I_j^{\text{отр}}(\alpha') \sim E_j^{\text{отр}}(\alpha') \sim \sigma T_0^4 \frac{A_j}{\eta_j} \frac{\varphi_j(\alpha')}{R^2}, \qquad (3)$$

where E_j^{refl} (α') - energy, reflected by j-point; T_0 - temperature of absolutely black body, emitting energy, equal to solar constant; R-distance to the Sun, a.e.; A_j - albedo (brightness factor); η_i - grayness coefficient; $\varphi_j(\alpha)$-phase function.

The coefficient of proportionality in expressions (2) and (3) is identical. It equals

ak(t), omega

where a is the sensitivity of the apparatus at the initial moment t_0 ; k(t)- multiplier, taking into consideration the change in sensitivity in time; omega - solid angle, cut out by the receiving area of the thermoelement.

From equations (2) and (3) for moments t and t' and the phase angles corresponding to them α and α' we find

$$T_i^4(\alpha) = \frac{T_0^4}{R^2} \frac{I_i^{\text{ик}}(\alpha)}{I^{\text{отр}}(\alpha')} \frac{A_j}{\eta_j} \varphi_j(\alpha') \frac{k(t')}{k(t)}. \qquad (4$$

Or taking into consideration that

$$I_i^{\text{ик}}(\alpha) = \frac{J_i^{\text{ик}}(\alpha)}{\rho_i(\alpha)} \quad \text{и} \quad I_i^{\text{отр}}(\alpha') = \frac{J_j^{\phi}(\alpha')}{\rho_\phi \rho_j(\alpha')}, \qquad (4a)$$

where $\rho_1(\alpha)$ - passing by instrument and atmosphere of thermal radiation, ρ_j (α') - the very same value for the reflected radiation, we will obtain

$$T_i(\alpha) = \frac{T_0}{R^{1/2}} \sqrt[4]{\frac{J_i^{\text{ик}}(\alpha)}{J_j^{\text{отр}}(\alpha')} \frac{\rho_\phi \rho_j(\alpha')}{\rho_i(\alpha)} \frac{A_j}{\eta_j} \varphi_j(\alpha') \frac{k(t')}{k(t)}}. \qquad (5)$$

When $\alpha' = \alpha$ and i = j term (5) transforms into an ordinary formula by Mensel

$$T_i = \frac{T_0}{R^{1/2}} \sqrt[4]{\left(\frac{\rho_\phi}{w_i} - 1\right) \frac{\rho_i}{\rho_i} \frac{A_i}{\eta_i} \varphi_i(\alpha)}, \qquad (6)$$

where $$w_i = \frac{J_i^{\phi}}{J_i^{\text{ик}}}. \quad (6a) \qquad (6a)$$

This formula was used in the combined operation of A.V.Markov and the author [3].

But calculation by formula (6) of temperature of small sections at considerable phase angles may lead to substantial errors, since the radiometric values A_i^{rad}, η_i, $\varphi_i^{rad}(\alpha)$ for individual sections are unknown. In case, if the sensitivity of the apparatus would be constant or there would be the possibility of controlling its relative change, it would be possible to obtain $\varphi_i^{rad}(\alpha)$ directly from observations, or

$$\varphi_i^{рад}(\alpha)=\frac{I_i^{отр}(\alpha)}{I_i^{отр}(\alpha'=0)}. \qquad (7)$$

The values I_i^{refl} ($\alpha' = 0$) were measured close to full Moon.

At present time the values of radiometric albedo of individual points are unknown. Pettit [1] determined only the mean albedo for the disk $A_0^{rad} = 0.135$.

It can be assumed, that radiometric and visual albedo of points are connected with mean values A_0 in the following manner:

$$A^{рад}=\frac{A^{виз}}{A_0^{виз}}A_0^{рад}. \qquad (8)$$

The sign $\odot$ designates the mean albedo for the disk. The value A^{vis} for individual points and the value A_0^{vis} are listed for example , in the Sytinska report [5].

Sections cut out by the receiving area of the thermoelement are heterogeneous, they, as a rule, contain also sea and continental formations. That is why the albedo of the section should be calculated by formula

$$A_i^{rad} = \frac{A_{sea}^{rad} \cdot S_{sea} + A_{cont}^{rad} S_{cont}}{S}$$

whereby $S = S_{sea} + S_{contin}$.

Here A_{sea}^{rad} and A_{cont}^{rad} - radiometric albedo of the sea and continent respectively, S_{sea} and S_{cont} - areas, occupied by sea and continent.

The values A_{sea}^{rad} and A_{cont}^{rad} were found by formula (8) for points, situated within limits of measured sections or near them. In order to reduce errors, originating at such a method of determining A_i^{rad}, it is possible to introduce into formula (4) instead of individual values A_i and I_i their mean value:

$$\bar{A}^{\text{рез}} = \frac{1}{n}\sum_{1}^{n} A_i^{\text{рез}},$$

$$\bar{I}^{\text{отр}} = \frac{1}{n}\sum_{1}^{n} \frac{J_i^{\phi}(0)}{p_i(0)}, \qquad (8a)$$

where n - total number of measured sections.

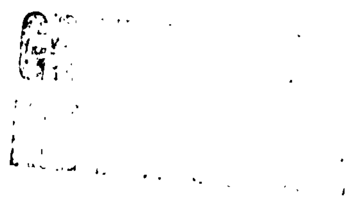

Fig.1.Thermoelement in Newton focus 13" reflector: 1-thermoelement; 2-adjustment ocular.

The grayness coefficient was acceptes as uniform for all sections and equalling 0.9. The final expression for $T_i(a)$ will then acquire the form of

$$T_i(a) = \frac{T_0}{R^{1,2}} \sqrt[4]{\frac{A^{\text{рез}}}{\gamma_i}\,\frac{1}{I^{\text{отр}}_{(0)}}} \times \sqrt{\frac{J_i^{c}(a) - \frac{J_i^{\phi}(a)}{n}}{p_i(a)}\,\frac{k(0)}{k(t)}} \qquad (9)$$

The observation material used in the experiment, was obtained on a 13" reflector of the Abastumansk observatory. As radiation receiver served a compensation thermoelement (fig.1) with fluorite window with a sensitivity of about 10 v/w set in Newton focus of the reflector. The thermoelement was made at the laboratory of prof.B.P. Kozyrev at LETI. It receiving areas had the form of squares with 0.7 mm sides, which during the focusing of the instrument at 1600 mm enabled to mark on the image of the Moon sections with a dimension of 1'.5 X 1'.5.

The construction of the thermoelement assured reliable jointing along the selected section. The thermal current was registered with an M-21/5 galvanometer, with a sensitivity of $3 \cdot 10^{-9} \frac{\text{a.m.}}{\text{mm}}$. Deviations of the galvanometer were recorded on photo paper.

The filter — intended to separate the reflected beam, represented a glass bulb, filled with glycerin. The thickness of each of the bulb walls - 4 mm, thickness of glycerin layer - 10 mm. The filter was placed directly in front of the thermoelement (fig.2). When the filter was introduced in the converging beam the focus of the instrument was increased somewhat. Refocusing and movement of the filter were realized by electric motors.

The observations were carried out for a period of three nights in March of 1959, selenographic coordinates of the measured sections are given in table 1. Their position on the disk is shown in fig.3. Directly from the observations were obtained the values of rejects $J_1^{\Sigma}(\alpha)$ and $J_1^{cp}(\alpha)$. Further processing was done in accordance with the theory, explained above.

Fig.2. Glycerin filter; 1-glycerin filter; 2-motors for shifting the filter and refocusing.

The magnitudes of passing the reflected and thermal radiations were obtained in the following manner. It is known, that passing into the IK zone of the spectrum is determined fully by the presence of strong water vapor absorption bands. If its amount is definite, e.g. according to data of sounding the atmosphere, then the calculation of absorption is done on the bases of Adel' data [6], by the previously used method [3]. However in Abastumani it was impossible to determine the amount of water vapor in an experimental way. Consequently it became necessary to use Hann's empirical formula. This formula binds the amount of water vapor in the column of the atmosphere over 1 cm^2 of terrestrial surface (so-called settled water) with absolute humidity at the surface. It has the form of

$$d = 1{,}7\, e_w. \qquad (10)$$

where d - settled water, cm. e_w - absolute humidity, cm.

On the days of obeservation d varied from 0.35 to 0.55 cm. Since formula (10) has a statistical sense, one can doubt in the reality of these fluctuations.

Fig.3. Position of measured sections on the Lunar disk. Numbers correspond to numbers of sections, point dehotes position of subsolar point.

Consequently during the processing was adopted a mean value d = 0.5 cm for three nights. The error in determining the final temperature value was calculated by us under the assumption, that the error d may reach 100%.

The passing coefficient, for reflected radiation were obtained on the basis of spectral coefficients of transparency, measured by Foul [7] at Mount Wilson. The acceptance of his results is due to the fact, that the transparency coefficients for Abastumani [8, 9] in the interval of wave lengths of 0.38 - 0.43μ and 0.53 - 0.57μ are close to the Foul coefficients for the very same intervals . Transparency coefficients in a much longer wave zone for Abastumani have not been determined.

Losses in optics have been considered on the basis of passing curves of the fluorite and glycerin filter, obtained in the laboratory of B.P.Kozyrev. The reflection coefficients of the mirrors were accepted as equalling 0.95 for the long wave and 0.85 for the short wave.

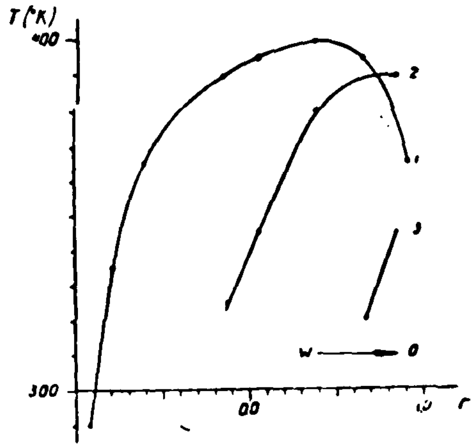

Fig.4. Temperature distribution along intensity equator.
1-25/26 III 1959; 2-28/29 III 1959; 3- 31/1 III/IV 1959

The value I_{rad} = 0.128 determined by formula (9) for twelve points, observed at minimum phase angle, equal to + 17°,2. At such a phase angle the phase function plays already an important role, that is why it must be introduced into expression (9). A mean value $\bar{\varphi}$ (17°,2) = 0.77, used by Pettit [2], was used for the entire Moon.

Finally it can be assumed, that $\frac{k(0)}{k(t)} \cong 1$, because the drop in sensitivity of the thermoelement for the period of observation (7 days) is disregarded little.

After substituting the numerical values formula (9) acquired the form

$$T_i(\alpha) = 88^\circ \sqrt[4]{\frac{J_i^{\Sigma}(\alpha) - \dfrac{J_i^{TP}(\alpha)}{r_\Phi}}{\rho_i^{TM+\Phi A}(\alpha)}}, \qquad (11)$$

where $\rho_i^{atm+fl}(\alpha)$ - combined passing by atmosphere and fluorite of thermal radiation.

Results of processing the observations are listed in table. Temperature distribution along the intensity equator are shown in fig.4.

The mean square error of absolute temperature value equals ± 30°. The internal convergence of the result is alm t doubly higher, because it is affected only by the errors of measuring the registrograms and by the error of magnitude $\rho_i^{atm+fl}(\alpha)$.

Table

Nr. of sections	Position of section	beta	lambda	T (°K)		
				25/26 – III α = +17°.2	28/29 – III α = +51°.9	31/I–III–IV α = +97°.1
1.	Continent toward SW from Sea of Profusion	−7°	+70°	290	—	—
2.	Sea of Profusion	−3	+49	335	—	—
3.	Continent toward O from Sea of Profusion	−3	+34	365	—	—
4.	Continent NW from Gimparch	−2	+9	390	325	—
5.	Continent NE from Ptolomeus	−1	−4	395	345	—
6.	Oceanus Procellarum to W of Landsberg	+3	−22	400	380	—
7.	Oceanus Procellarum between Kepler and Flamstid	+3	−41	395	—	320
8.	Oceanus Procellarum between Flamsteed and Grimaldi	−4	−53	—	39[illegible]	345
9.	Continent to north of Gevelinia	+5	−72	365	—	—
10.	Mare Imbrium to SE from Archimeda	+23	−11	398	—	—
11.	Apennines	+17	+1	391	—	—
12.	Sea of Clouds	−15	−1[illegible]	393	—	—
13.	Continent at Alphons	−15	−2	384	—	—

The obtained results allow to draw the following conclusions.

1. Within limits of ———— errors of the subsolar point for phase $\alpha = +17°,2$ the temperature coincides with its theoretical value of 385°, obtained by Pettit for full Moon.

2. As is evident from comparing points 10, 11 and 12,13 the temperature of the seas is higher than the temperatures of the continents adjoining same.

In spite of the fact, that the difference in temperatures is less than 10°, it is no doubt real. The fact is, the ratio of the sub-root ——— expressions of formula (10) gives

$$\frac{J_{\text{мрк}} - \frac{J^{\text{отр}}_{\text{мрк}}}{\rho_\Phi}}{J_{\text{море}} - \frac{J^{\text{отр}}_{\text{море}}}{\rho_\Phi}} \cdot \frac{\rho_{\text{море}}}{\rho_{\text{мрк}}} = \frac{E^{\text{ик}}_{\text{мрк}}}{E^{\text{ик}}_{\text{море}}} = \frac{J^{\text{ик}}_{\text{мрк}} \cdot \rho_{\text{море}}}{J^{\text{ик}}_{\text{море}} \cdot \rho_{\text{мрк}}}. \tag{11}$$

Since at the time of measuring two adjacent points the atmospheric conditions do not change substantially, it can be assumed that $\rho_{M.K} = \rho_{sea}$.

Then

$$\frac{J^{\text{ик}}_{\text{мрк}}}{J^{\text{ик}}_{\text{море}}} = \frac{E^{\text{ик}}_{\text{мрк}}}{E^{\text{ик}}_{\text{море}}}. \tag{12}$$

For each pair of points calculations give $\frac{E^{ik}_{sea}}{E^{ik}_{sea}} = 0.93 \pm 0.02$.

3. The latter indicates the correctness of equation (8). It is apparent that

$$\frac{E^{\text{ик}}_{\text{мрк}}}{E^{\text{ик}}_{\text{море}}} = \frac{1 - A^{\text{виз}}_{\text{мрк}}}{1 - A^{\text{виз}}_{\text{море}}}. \tag{13}$$

Having substituted here the values A from (8) we will obtain a mean value for two pairs

$$\frac{E^{\text{ик}}_{\text{мрк}}}{E^{\text{ик}}_{\text{море}}} = 0{,}95 \pm 0{,}02, \tag{14}$$

which is in excellent conformity with previous result. It means that the ratio of visual and radiometric albedo of individual points is equal to the very same ratio of average albedo along the disk.

The obtained results point toward the possibility of sufficiently reliably determining the temperature of individual sections of lunar surface, by using the given apparatus and method. To increase the accuracy it is necessary to know positively the amount of settled water and have the possibility of controlling the sensitivity of the apparatus. The obtainment of larger volumes of observation material with consideration of the above stated will allow to make definite conclusions about the structure of upper layers of the lunar crust.

In conclusion I consider it an obligation to express thanks to the director of the Abastumansk observatory for offering the possibility of obtaining observation

material, thanks to prof.B.P.Kozyrev for the thermoelements developed by him, and to Dr of Phys.Math Sc.A.V.Markov for his supervision over the scientific functions.

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Indicatrices of Reflection of Individual Sections of the Lunar Surface

by

N.P.Barabashov; V.I.Yezerskiy

By applying the principle of optical reciprocity to data of a photometric catalogue of the lunar surface V.A.Fedorets[2] obtained indicatrices of reflection of individual sections of the lunar surface and a comparison of same was made.

A graphic and convenient form of presenting the dependence of reflected properties of surfaces appears to be a reflection indicatrix.

For the surface of the Moon the reflection indicatrix was first derived by N.S. Orlova[1]. For this purpose N.S.Orlova used date of photometric catalogues[2,3] on the reflectivity of lunar details and finally obtained indicatrices for the reflection of continents and seas, situated along the intensity equator, assuming, that for each type of objects there is a photometric homogeneity.

Later N.P.Barabashov and V.I.Garazha[4] having applied principally the very same method, have also formulated indicatrices of reflection for continents and seas, situated along the intensity equator.

In the above mentioned experiments were revealed a difference, true, very insignificant, in the form of continent and sea indicatrices, which should be caused in turn by a certain difference in microstructure, defining the reflection indicatrix.

It appears to be interesting to formulate reflection indicatrices also of individual sections of the lunar surface (even if for single values of the angle of incidence), situated not only near the intensity equator, but also over the entire lunar disk. These data should allow for a more definite comparison of reflective properties, and consequently, also the microstructure of details of various morphological types and situated in various sections of the lunar disk.

For this purpose were used data of the photometric catalogue of V.A.Fedorets [2]. The processing consisted in the following.

From the data available for each detail concerning the dependence of brightness upon the phase angle alpha, angle of incidense and angle of reflection ξ were selected only these values, which could possibly envelop a greater range of angle of incidence values i at ξ, distinguished by not more than $\pm 1^\circ$, and sometimes even not more than $\pm 0^\circ.5$.

In order to take under consideration the difference in albedo, the brightness values were brought, in unison, to a value, corresponding to a minimum value of the phase angle ($\alpha = 1^\circ.5$).

Using the reciprocity principle introduced by Minnaert [5], according to which $\frac{B(i, \xi)}{B(\xi, i)} = \frac{\cos i}{\cos \xi}$, we will obtain the interesting us dependence of the brightness upon the angle of reflection at a fixed value of the angle of incidence.

Compared will be sections, the selenographic longitudes of which are not too much different and which are situated symmetrically relative to the intensity equator. If we were to introduce additionally the law of signs for reading the angles of reflection, then we could also compare sections, for which $\lambda_1 \approx \pm \lambda_2$ and $\varphi_1 \approx \pm \varphi_2$.

This law consists in the following. If the value of the selenographic longitude of the detail is included within the limits of the interval, enveloped by the selenographic longitudes of the Sun and Earth, and the incident and reflected ray lies as if along various sides of the normal, then a negative value is accepted. Otherwise, when $\lambda_\odot$, and λ_t lie on one side from λ, we consider the angle as positive. Furthermore, it should be taken into consideration, that the minimum attainable value of the angle of incidence, and after transformation of the reflection angle, it becomes approximately equal to the selenographic longitude of the detail.

This rule was taken into consideration when plotting graphs fig.1-11, on which final data are presented. And so, to the left of ξ_{min} are situated negative values, to the right of it - positive ones.

On all graphs are given the numbers of details according to the catalogue [2], their names, selenographic coordinates and values of the incidence angle.

Examination of data given in fig.1-11 lead to the following conclusions.

1. As a rule, the data of the compared sections close to each other, in any event, within limits of possible errors, and their indicatrices to coincide. This pertains above all to sections, where brightness rises rapidly and reaches maximum value. For values of reflection angles , exceeding 40-50°, in sections, sufficientlt removed from full Moon, there are sometimes noticeable discrepancies. This may be due to the difference in inclinations of the effective, in the given interval of angles, phase and reflection angle of the reference surfaces. But the coincidence of indicatrices in the zone of rapid rise and drop of brightness it should be due to the shade effect of the reference-surface of a much higher magnitude. Attention is attracted by the close coincidence of indicatrices of details No 37, 167 (continents) and No.89, 160 (seas), shown in fig.3.

Impressive are also data fig.6, where are presented the marginal sections ($\lambda \approx \pm 60°$).In this case coincide also the displacements of the brightness maximum with respect to full Moon.

All the characteristics revealed during comparing the reflection indicatrices of individual sections are supplemented and the previously made conclusions about photometric homogeneity of the lunar surface [6] are being developed.

2. The indicatrices of light rays and situated in line with the zones coincide also in details, which confirms the previously made [6] conclusion about the fact that light rays acquire photometric structure of these areas, in which they are situated. This can take place under a condition , if the particles of the substance of light rays have dimensions considerably smaller than microrelief irregularities,determining the indicatrix of surface reflection, and are arranged over that surface in a sufficiently thin layer.

3. A noticeable divergence in indicatrices is revealed when comparing (fig.10) the central part of the Clavius crater with inner and outer inclinations of its shaft. The brightness of the shaft increases more rapidly, than the brightness of the central part of the crater. As is evident from fig.11, is also defined the Wood spot possessing, in entire visibility, a greater degree of dug up relative to the compared zones.

Some calculations for the present experiment were made by O.Starodubtseva, for which I do express my thanks.

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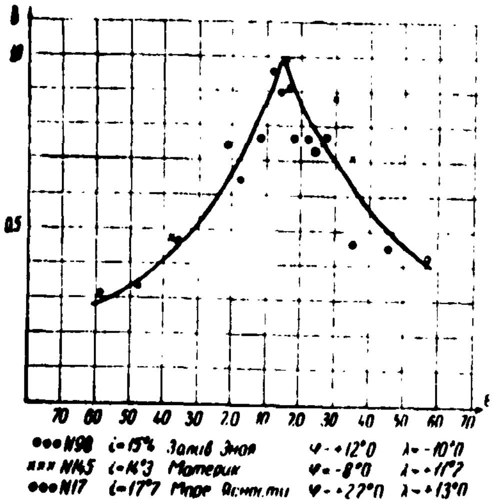

Fig.1. ...Torrid gulf
***continent
oooBrightness Sea

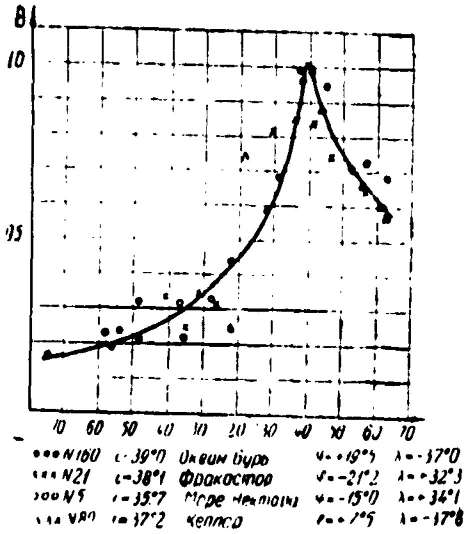

Fig.2. ...Oceanus Procellarum
*** Fracostor
oooNectar Sea
ΔΔΔ Kepler

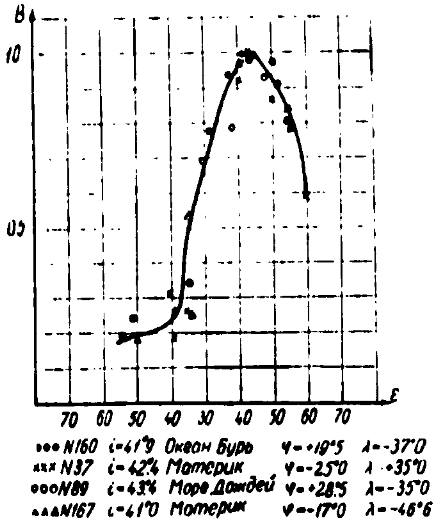

Fig.3. ...Oceanus Procellarum
*** Continent
ooo Mare Imbrium
ΔΔΔ Continent

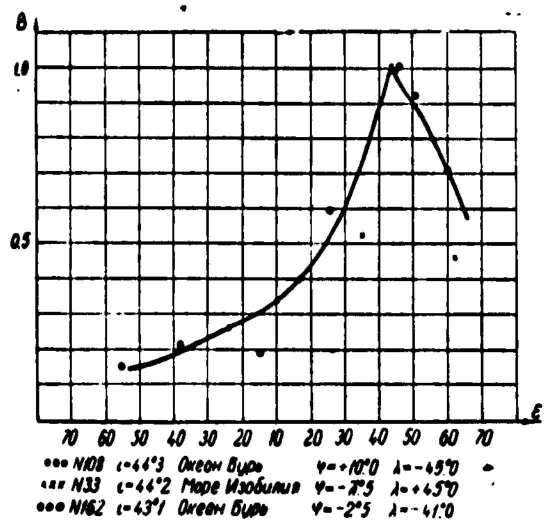

Fig.4. ... Oceanus Procellarum
*** Profusion Sea
ooo Oceanus Procellarum

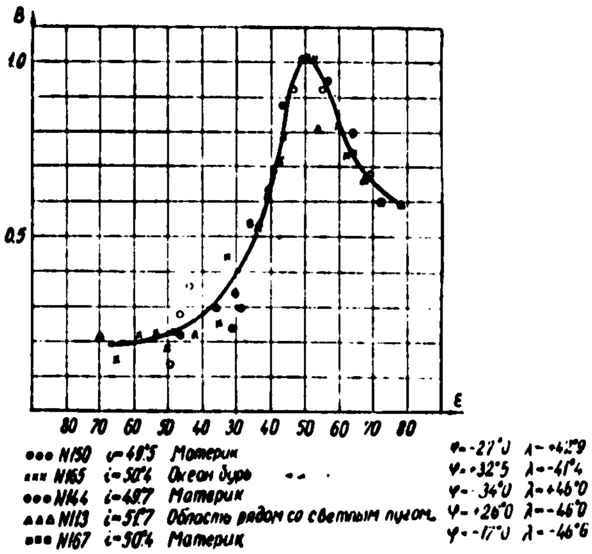

Fig.5. ...Continent
***Oceanus Procellarum
000 Continent
ΔΔΔ Zone in line with bright apron
□□□ Continent.

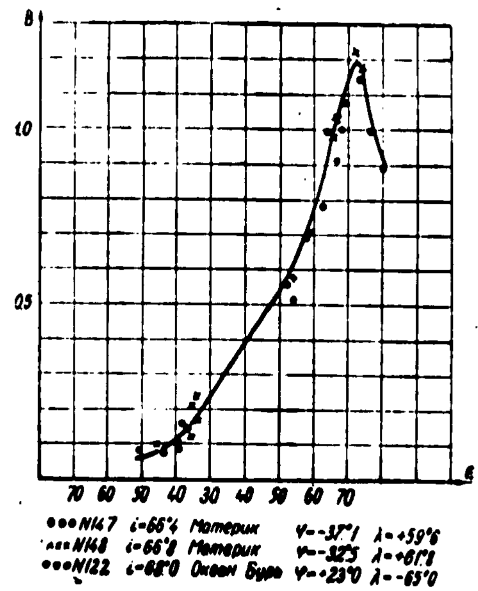

Fig.6. ... Continent
*** continent
ooo Oceanus Procellarum

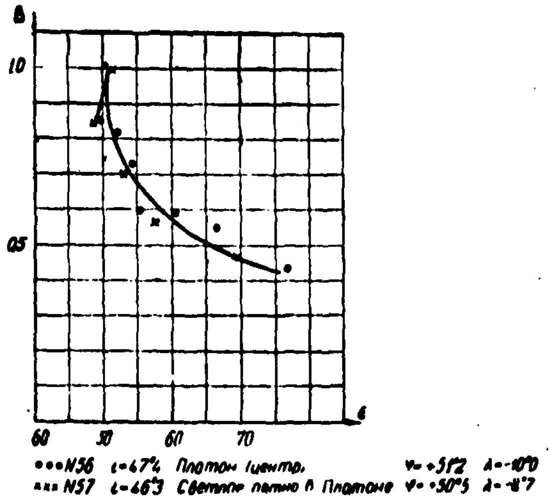

Fig.7. ... Platon (center)
***** Bright spot in Platon**

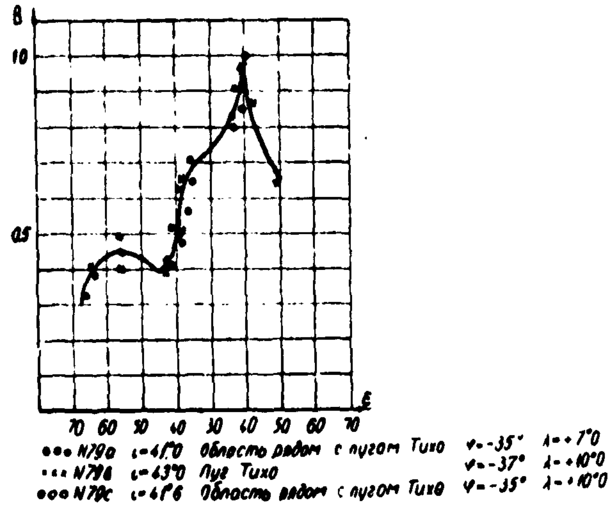

Fig.8. ... Zone in line with Ticho (Tycho) plain
***** Tycho plain**
ooo Zone in line with Tycho plain

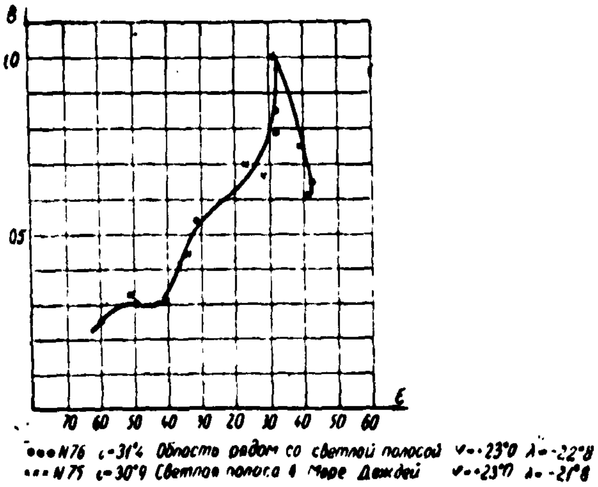

Fig.9. Zone in line with bright band
***** Bright band in the Mare Imbrium.**

See Page 17a

Fig.10...Clavius (center)
***** internal inclination of Clavius shaft**
ooo outer inclination of Clavius shaft

See Page 17a

Fig.11...Aristarch
***** Oceanus Procellarum ooo Light arc along Aristarch ooo And spot.**

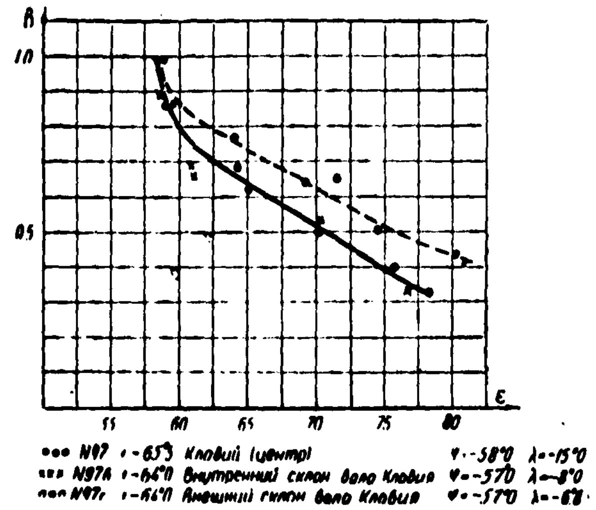
B
1.0
0.5
ε
55 60 65 70 75 80
••• N97 i = 65°3 Клавий (центр) φ = -58°0 λ = -15°0
N97A i = 64°0 Внутренний склон вала Клавия φ = -57°0 λ = -8°0
N97г i = 66°0 Внешний склон вала Клавия φ = -57°0 λ = -6°8

Fig. 10

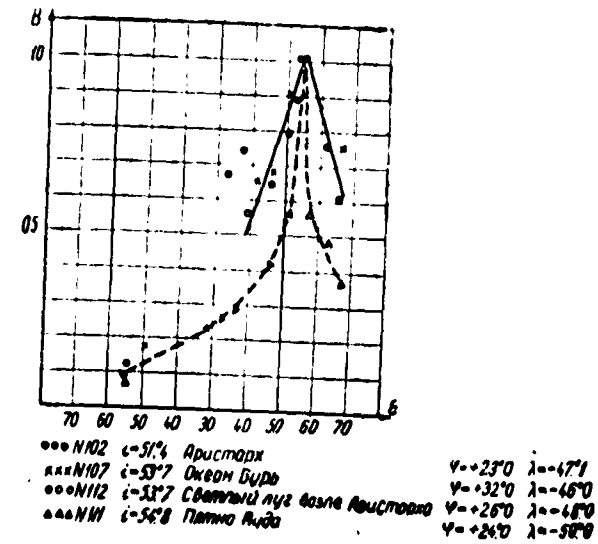
B
1.0
0.5
ε
70 60 50 40 30 40 50 60 70
••• N102 i = 51°4 Аристарх
N107 i = 53°7 Океан Бурь φ = +23°0 λ = -47°1
N112 i = 53°7 Светлый луг возле Аристарха φ = +32°0 λ = -46°0
N111 i = 54°8 Пятно Аида φ = +26°0 λ = -48°0
φ = +24°0 λ = -50°0

Fig. 11

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